ORGANIZAÇÕES

A THEORY OF ORGANIZATIONAL COGNITION: PRINCIPLES AND CONCEPTS

A TEORIA DA COGNIÇÃO ORGANIZACIONAL: PRINCÍPIOS E CONCEITOS

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RESUMO

Organizações e mudanças do ambiente ao longo do tempo. Não é só mudar as suas estruturas e processos de funcionamento, mas também as perspectivas que os investigadores têm acerca deles por períodos de tempo. Assim, os cientistas precisam fazer uma revisão das teorias das organizações, a fim de formular novas soluções para os problemas do presente. É nesse sentido do pensamento que esse trabalho contribui através da introdução de novos conceitos, princípios e proposições para uma teoria da cognição organizacional. É colocado novas perspectivas sobre a organização e o ambiente, e também sobre as relações entre eles através do conceito de cognição. A partir dessas origens, esta investigação contribui também por apresentar os conceitos de autonomia e inteligência organiza-cional, níveis hierárquicos da cognição nos sistemas organizacionais, juntamente com definições cognitivas e modelos complexos de organização e do ambiente.

PALAVRAS-CHAVE

Organizações. Ambiente. Cognição. Sistemas complexos. Fuzzy sets.

ABSTRACT

Organizations and the environment change over time. Not only change their structures and processes of functioning, but also the perspectives that researchers have about them over periods of time. Hence, scientists need to review theories of organizations in order to formulate new solutions to the problems of the present. It is in such a direction of thinking that this paper contributes by introducing new concepts, principles and propositions towards a theory of organizational cognition. It put forwards new perspectives about the organization and the environment, and also about the relations between them through the concept of cognition.

From these backgrounds, this research also contributes by presenting the concepts of organizational intelligence and autonomy, hierarchic levels of cognition in organizational systems, along with cognitive definitions and complex models for the organization and the environment.

KEYWORDS

Organizations. Environment. Cognition. Complex systems. Fuzzy sets.

INTRODUCTION

Principles of organizations evolved with ancient and medieval civilizations, and developed and matured after the Industrial Revolution in Europe in the 18th century and latterly in the United States of America in the 19th century. Such a transformation flourished gradually after the apogee of the Renaissance and the Enlightenment Ages in Europe which was marked by a period of revolution in thinking, supported by religious, economic, social, technological and political changes (WREN, 1987). The gradual maturation of organizations was encompassed by transformations in the perceptions, behavior and motives of their participants, developments in technology, the need for new organizational processes and structures of normative and behavioral parts, the human desire to pursue more complex goals, developments in social sciences, behavioral and cognitive psychology along with general systems theory, changes in the environment, and also due to intensive processes of globalization (NOBRE, 2008).

Modern organizations emerged gradually after the Industrial Revolution and they were challenged by new political, economic, social and technological contexts. Hence, schools of organizations and management were developed in order to support the analysis of the new organization and the design of new organizational structures and processes. Such schools emerged from the first decade of the 20th century, giving rise and maturation to the discipline of organization theory (KHANDWALLA, 1977; MARCH, 1965; SCOTT, 1998). They started with theories of bureaucracy, principles of scientific management and administrative theory, and they received new insights from the experiments of the human relations school (PUGH, 1997). They advanced with the contributions provided by the schools of administrative behavior and decision-making (MARCH; SIMON, 1958, 1993; SIMON, 1947, 1997B), systems theory (SILVERMAN, 1970), socio-technical systems (TRIST, 1981), contingency theory (GALBRAITH, 1973, 1977), organization design (GALBRAITH, 2002), economic organizations (MILGROM; ROBERTS, 1992), computational organizational theory (CARLEY; GASSER, 1999), organizational learning (DIERKES *et al*., 2003), organizational cognition (NOBRE *et al*., 2008), among other schools. In such a path, organization theory has reached the 21st century as a formal and mature discipline supported by the rigorous contributions of these schools.

The literature about organization theory has also provided distinct, complementary and common perspectives on organizations. The publications encompass books which cover different writers of organizations (PUGH; HICKSON, 1997), diverse types of organizations (MCKINLAY, 1975; MARCH, 1965), prominent comparative studies of different classes of organizations (BLAU; SCOTT, 1963), and also references that broadly survey literature results (HODGE *et al.,* 2003; SCOTT, 1998).

These evolutions and diversities of schools of organizations exist because the organization and the environment change over time. Not only

change their structure and processes of functioning, but also change the perspectives that researchers have about them over periods of time. Hence, scientists need to review theories of organizations in order to formulate new solutions to the problems of the present. It is in such a direction of thinking that this paper contributes by proposing new concepts, principles and propositions towards a theory of organizational cognition. It comprises the selection of diverse perspectives of organizations and also the unification of them towards a new organizational theory whose principal element is cognition. Its content is mostly influenced by the contributions given by the schools of administrative behavior, decision-making and bounded rationality (MARCH; SIMON, 1993; SIMON, 1997a, 1997b), systems theory (BUCKLEY, 1968; KHANDWALLA, 1977), socio-technical systems (TRIST, 1981), contingency theory (GALBRAITH, 1973, 1977), organizational learning and knowledge management (DIERKES *et al.,* 2003), computational organization theory (CARLEY; GASSER, 1999) and also the perspectives of rational, natural and open systems (SCOTT, 1998).

Initial lines of contribution as outlined in this paper to the perspectives of organizational cognition were first touched in (NOBRE, 2002, 2003a, 2003b, 2004a, 2004B). Latterly, these perspectives were further developed and extended to new concepts, theories and practices about organizational cognition that subsume cognitive machines in organizations (NOBRE, 2005, 2008; NOBRE *et al.* 2008). In these publications, the authors also presented evidence through empirical research that indicates the alignment of their premises and propositions with results of an industrial case study that also contributed to outline new directions to assess, to evaluate and to measure the degree of organizational cognition. Therefore, it is from these backgrounds that this paper presents its contributions. It outlines rationale, concepts, principles and propositions towards a theory of organizational cognition.

From a macro point of view, what makes this paper distinct is that it put forwards new perspectives about the organization and the environment, and also about the relations between them through the concept of cognition. In such a view, organizational cognition is contingent upon the environment. Moreover, this paper focuses on the general picture of organizations pursuing high degrees of cognition in order to reduce the relative levels of uncertainty and complexity of the environment. Therefore, it does not discriminate organizations by their type and purpose (i.e., profit or non-profit industries, public or private institutions, manufacturing and service firms, unions, armies, schools, and so on); nor by their size; nor by their geographical location, east-west; and nor by their age.

From a micro point of view, this research proposes principles about organizational cognition and it clearly distinguishes organizational cognition from the concept of organizational learning. It outlines the concept of hierarchic levels of cognition in organizational systems and thus it proposes cognition as an important element of the organization. It presents definitions of organizations, environment along with the relations between them through cognitive perspectives. Such definitions include concepts of intelligence, cognition, autonomy and complexity for organizations. It derives a definition of environmental complexity and it proceeds by introducing propositions about the relations between organizational complexity and environmental complexity. While the former is synonymous with organizational cognition, the latter is synonymous with environmental uncertainty. All these backgrounds together form a theory of organizational cognition and they support the perspective of organizations pursuing high degrees of cognition.

CRITICAL VIEW AND MOTIVATIONS

Organizational cognition is a discipline which has its foundations based on multidisciplinary

research areas that span from social sciences, economics, business administration, management, sociology, political science, anthropology, philosophy, psychology, information systems, cognitive sciences and computer sciences to other areas that play an important part in organizational studies, organizational behavior and organizational theory (NOBRE *et al.,* 2008).

The subject of organizational cognition has been touched in the literature after advancements in the discipline of organizational learning which has received important and diverse contributions from distinct researchers (ARGYRIS; SCHON, 1978; MARCH; OLSEN, 1975; SENGE, 1990).

Multidisciplinary studies on organizational learning and knowledge management are presented in (DIERKES *et al.* 2003); and on organizational intelligence, and organizations resembling information processing systems and distributed computational agents are presented in (BLANNING; KING, 1996; CARLEY; GASSER, 1999; PRIETULA *et al.,* 1998). However, a formal study which relates organizations with concepts of cognition and learning (innovation) was previously and firstly proposed in (SIMON, 1947; MARCH; SIMON, 1958; SIMON, 1997b).

Nevertheless, despite existing some connections in between organizational learning, knowledge management, organizational intelligence and organizational cognition, this latter subject has began to receive more attention only from the beginning of the 21st Century, after some book publications. The edited book by Lant and Shapira (2001) for example, presents a collection of chapters on the subject of cognition and its impact on organizational studies. Contributors to their book chapters include well-known researchers such as James March and Willian Starbuck. However, despite providing the literature with a set of chapters that introduce many perspectives on the general subject of organizational cognition, Lant and Shapira's book does not give a concise definition of organizational cognition. Moreover, and most important, it does not make a clear distinction between the concepts of organizational cognition and organizational learning, knowledge management, among other related terminologies which have been used through an interchangeable way in most of the literature on these subjects. Another publication which does not clearly distinguish these terms is the book of Iandoli and Zollo (2007).

Proceeding further, what makes this paper distinct and unique is that it provides a set of principles, definitions, premises and propositions towards a theory of organizational cognition. It clearly derives definitions on organizational cognition and it also distinguishes organizational cognition from organizational intelligence, organizational complexity, organizational autonomy and organizational learning. Moreover, it sets cognition as an important element of the organization. From all these backgrounds, this research raises a number of questions in our quest for answers and it opens new directions for future research on organizational cognition, organization design, analyses of cognitive machines in organizations and also methods to assess, to evaluate and to measure the degree of organizational cognition (NOBRE *et al.,* 2008).

ORGANIZATIONS

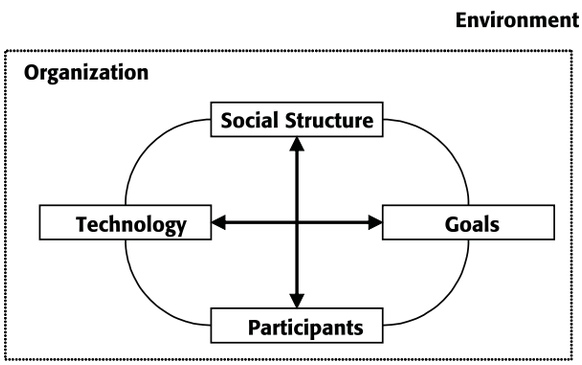
Model of the Organization

Organizations benefit individuals by extending their cognitive, physical, temporal, institutional, and spatial limitations (CARLEY; GASSER, 1999; NOBRE, 2008). They integrate participants, technology and goals into a coordinative social structure in order to cope with the environment. Participants are the agents which act in the name of the organization. Technology expands what organizations can do and it supports the connection of the organization to the environment. Goals and sub-goals are what organizations aim to achieve in order to satisfy their desires. Social structure

refers to the standards and regularized aspects of the relationships existing among the participants in the organization; it comprises normative and behavioral structures (NOBRE, 2008). The environment includes information, consumers and stakeholders, other organizations like buyers and suppliers, networks of organizations, institutions, market regulators, the whole economy, cultural values and natural resources (MILGROM, ROBERTS, 1992; SCOTT, 1998). Figure 1 illustrates a model for the organization. The elements of the organization are interdependent and the whole organization is connected with the environment.

Figure 1

A Model of the Organization (Scott, 1998)



Limitations of Organizations

Contingency theory (GALBRAITH, 1973, 1977) has defined uncertainty as the variable which makes the organization contingent upon the environment. Hence, organization design, and thus organizational choice, depends on the concept of uncertainty. Briefly, uncertainty can be associated with the mathematical concepts of probability and fuzziness (KLIR; FOLGER, 1988). However, uncertainty can also be associated with propositions of bounded rationality (NOBRE, 2008), by carrying the meaning of:

(a) Lack of information, which leads the organization to unpredictability of outcomes.

(b) And, insufficiency of cognitive abilities for general information-processing.

The former, lack of information, means that:

Definition 1: Uncertainty is the difference between the total amount of information that the organization needs to have in order to complete a task, and the amount of information in possession of the organization.

The latter, insufficiency of cognition, mans that:

Definition 2: Uncertainty is the difference between the degree of cognition that the organization needs to have in order to complete a task, and the degree of cognition in possession of the organization.

These two approaches to uncertainty complement each other and this paper proposes that:

Proposition 1: The greater the amount of information that the organization needs to have in order to perform and to complete a task, the greater is the degree of cognition that the organization needs to have in order to process and to manage this information for task execution and completion.

Figures 2 and 3 illustrate such concepts of uncertainty using symbolic scales of measurement.

Figure 2

Uncertainty as Lack of Information

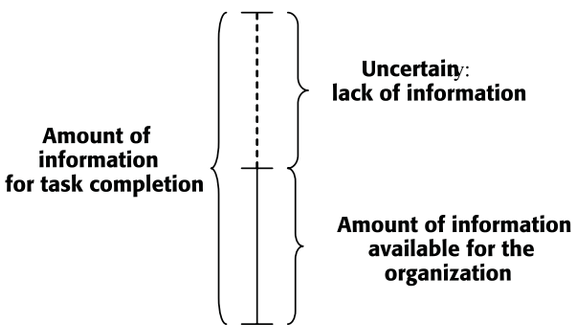
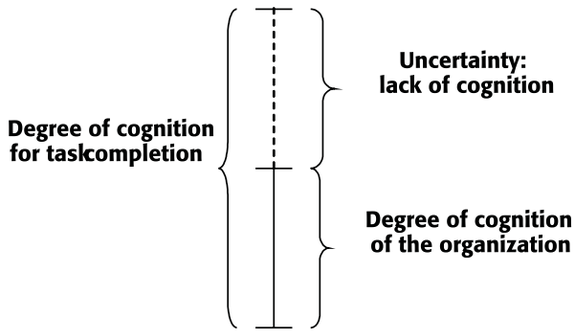


Figure 3

Uncertainty as Lack of Cognition



Therefore, the question which rises in our quest is: - what to do in order to reduce the level of uncertainty that the organization confronts and needs to manage? Organizational cognition and organization design have together an important role in the answer of this task (NOBRE, 2005, 2008).

ORGANIZATIONAL COGNITION

The Domain of Organizational Cognition

Like perception and emotion, cognition is a process or a set of processes that subsume attention, knowledge organization, decision-making and problem-solving. In such a way, the degree of cognition is synonymous with the level of elaboration and integration of such a set of processes.

Organizations resemble cognitive systems when they present abilities and processes for sensing, perceiving, filtering and attention; storing and organizing knowledge; problem solving, decision-making and learning. These processes are evoked by internal and external stimuli to the organization.

The perspective of organizations as lateral and vertical distributed cognitive agents was firstly touched upon in the work of March & Simon (1958, 1993). Later, this perspective was further extended to the concept of Computational Organization Theory (COT) in the work of Carley & Gasser (1999). This paper adopts these perspectives and it views the structure of the organization resembling a nexus of cognitive agents and processes which are organized through lateral and vertical relations. These cognitive agents are the participants within the organization and they can subsume humans and cognitive machines (NOBRE, 2008). Agents also can represent a department, a division, a unit, or any part in the organization. They exchange information between them and with the organization environment through the use of protocols of communication, and they are coordinated according to the organization's social structure.

In a broad sense, cognition develops in order to increase the probability of humans to survive (PLUTCHIK, 1982). Similarly, organizational cognition has the same function.

Human vs. Organizational Cognition

Human cognition is part of a natural system and hence it is not a man-made system. Therefore, the brain and the cognitive abilities of humans are more or less unchangeable.

Organizational cognition is part of an artificial system which is designed and hence it is a man-made system. Moreover, this type of system involves humans and machines. The cognitive abilities of organizations can be changed and improved through the process of organization design. Therefore, organizational cognition is contingent upon the goals, social structure, participants, technology and the environment of the organization.

The Discipline of Organization Cognition

A theory of organizational cognition is important and necessary when we decide to design organizations with higher capabilities of information processing and uncertainty management. In such

a way, organizational cognition is a discipline which contributes to improve the computational capacity of the organization along with its ability for knowledge management (NOBRE *et al.,* 2008).

Organizational cognition is concerned with the processes which provide agents and organizations with the ability to learn, to make decisions and to solve problems. The main agents of organizational cognition are the participants within the organization and the social networks which they form. In organizations, cognitive processes are supported by their goals, technology and social structure. Moreover, organizational cognition is also influenced by inter-organizational processes and thus by the environment. Therefore, the choice of the organization elements, and thus organizational design (GALBRAITH, 2002), plays a fundamental task in organizational cognition.

The cognition of the organization can be represented as a matter of degree whose level depends on the choice of the organization elements.

Ten Principles of Organizational Cognition

This section summarizes ten principles of organizational cognition which form the basis for the definitions, premises and propositions proposed in this paper. They are enumerated as:

(i)Organizational cognition is concerned with the processes which provide agents and organizations with the ability to learn, to make decisions and to solve problems.

(ii) A theory of organizational cognition is important and necessary when we decide to design organizations with higher capabilities of information processing and uncertainty management.

(iii) Organizational cognition is a discipline which contributes to improve the computational capacity of the organization along with its ability for knowledge and uncertainty management.

(iv) The main agents of organizational cognition are the participants within the organization and the social networks which they form. Agents subsume humans and cognitive machines.

(v) Cognitive processes are supported by the goals, technology and social structure of the organization. Moreover, organizational cognition is also influenced by inter-organizational processes and thus by the environment.

(vi) The cognition of the organization can also be represented as a matter of degree whose level depends on the choice of models of organizing.

(vii) The choice of organizing models, and thus organization design, plays a fundamental role in organizational cognition.

(viii) The capability of the organization for information processing, knowledge and uncertainty management, task execution, and management of complexities of the environment, depends on its degree of cognition.

(ix) The degree of cognition of the organization depends upon the choice of its elements, and the choice of the organization elements depends upon the environment. Consequently, organization cognition is contingent upon the environment.

(x) Organizational cognition supports knowledge management[1] and organizational learning[2] with processes that contribute to improve continuously the elements, the competitive advantage, and the results of the organization. Such results subsume equilibrium between the participants' motives and the organization goals;

[1] In resume, Knowledge Management (KM) subsumes a set of practices used by organizations to identify, create, represent, organize, and distribute knowledge for reuse, awareness and learning. In this paper perspective, KM is a sub-process of Organizational Cognition (OC), since this latter (OC) involves the former (KM).

[2] Shortly speaking, organizational learning is a field within organizational theory that studies learning and adaptive models for organizations.

customer satisfaction; organization performance and profitability.

ORGANIZATIONAL INTELLIGENCE, AUTONOMY AND COMPLEXITY

Definitions of organizational intelligence, autonomy and complexity are briefly presented in this section.

Organizational Intelligence

Intelligence is a general mental ability (SCHMIDT; HUNTER, 2000), which depends on rational and emotional processes. Organizations also pursue intelligence which is supported by their internal elements (participants, social structure, technology and goals). Additionally, like cognition, intelligence is a matter of degree. The relationship between organizational intelligence and cognition is defined by:

Proposition 2: The greater the degree of cognition of the organization, the greater is its chance to exhibit intelligent behavior.

Organizational Autonomy

This paper regards autonomy as the ability of an organism to act through the use of cognition. Additionally, like cognition and intelligence, autonomy is a matter of degree. Therefore, it proposes that:

Proposition 3: The greater the degree of cognition of the organization, the greater is its autonomy.

Organizational Complexity

This paper regards the level of complexity of the organization as contingent upon its degree of cognition. Therefore, the complexity of organizations are synonymous with their cognitions which are processes used to solve complex tasks. Hence, it is proposed that:

Proposition 4: The greater the degree of cognition of the organization, the greater is its ability to solve complex tasks.

ENVIRONMENTAL COMPLEXITY

The complexity of the environment is contingent upon the level of uncertainty that it represents to the organization. Similarly, the complexity of a task environment is contingent upon the level of uncertainty that it represents to the organization during task execution and completion. Therefore:

Proposition 5: The greater the level of task complexity, the greater is the level of task uncertainty.

Proposition 6: The greater the level of environmental complexity, the greater the level of environmental uncertainty.

Proposition 7: The greater the level of environmental complexity, the greater is the level of environmental uncertainty that the organization confronts and needs to manage.

ORGANIZATIONAL COGNITION AND THE ENVIRONMENT

This section presents premises in order to support propositions that relate the organization and the environment.

Premise 1: The elements of the organization (participants, social structure, technology and goals) support the organization with cognitive processes such as filtering and attention, storing and organizing knowledge, problem solving, decision-making and learning.

Premise 2: The degree of cognition of the organization is contingent upon the level of elaboration and integration of the organization processes.

Premise 3: The level of complexity of the organization is contingent upon its degree of cognition.

Therefore, it is proposed that:

Proposition 8: The higher the level of complexity of the organization, the higher is its degree of cognition.

Proposition 9: The higher the degree of cognition of the organization, the lower is the relative level of environmental complexity.

Proposition (9) does not mean that the level of complexity of the environment reduces, but that such a level of complexity is relatively reduced when compared to the growth in the level of complexity of the organization. Therefore, by associating propositions (7) and (9), it can be stated that:

Proposition 10: The lower the relative level of environmental complexity, the lower is the relative level of environmental uncertainty that the organization confronts and needs to manage.

Similarly, proposition (10) states that the level of uncertainty in the environment is relatively reduced if an increase in the degree of cognition of the organization occur. Therefore, the next theorem can be deduced from the previous chain of propositions:

Theorem 1: The higher the degree of cognition of the organization, the lower is the relative level of environmental complexity and uncertainty that the organization confronts and needs to manage.

HIERARCHIC LEVELS OF COGNITION IN ORGANIZATIONAL SYSTEMS

Studies of complex systems and their classification through hierarchical levels of complexity were proposed in (BOULDING, 1956; SIMON, 1996). In these studies, a system is defined as a large number of objects together with relationships between them and between their attributes or properties. The parts, elements or objects which form the systems vary from being very simple to very complex in structure, and from being highly stable to highly dynamic and variable in their interaction. Moreover, each system of higher level of complexity incorporates the features of those systems below it.

In such a context, this paper proposes that differences in the levels of complexity of systems reside not only in the properties and structure of their elements, but most importantly, in the abilities of these elements. The former, i.e., properties and structure, refers to physical, biological and chemical attributes of the system, and the latter, i.e., abilities, means cognition, intelligence and autonomy of the system.

Therefore, by analyzing the Boulding's typology that classifies systems according to their levels of complexity, it becomes evident to conclude that the higher the complexity of a system in the Boulding's classification scale, the higher is its degree of cognition, intelligence and autonomy. This classification of systems is enumerated from 1 to 9 in the order of growth of their levels of complexity (BOULDING, 1956):

(1) Frameworks: systems comprising static structures, such as the arrangements of atoms in a crystal or the anatomy of an animal.

(2) Clockworks: simple dynamic systems with predetermined motions, such as the clock and the solar system.

(3) Cybernetic Systems: systems capable of self-regulation in terms of some externally prescribed set point or target, such as a thermostat.

(4) Open systems: systems capable of self-maintenance based on a through-put of resources from their environment, such as living cells.

(5) Blueprinted-growth systems: systems that reproduce not by duplication but by the production of seeds or eggs containing pre-programmed instructions for development, such as the egg chicken system.

(6) Internal-image systems: systems capable of a detailed awareness of the environment in which information is received and organized into an image or knowledge structure of the environment as a whole. Animals function at this level.

(7) Symbol-processing systems: systems that possess self-consciousness and are capable of using language. Humans function at this level.

(8) Social systems: systems comprising agents functioning at level 7 who share a common social order and culture. Organizations operate at this level.

(9) Transcendental systems: systems composed of the absolutes and the inescapable unknowable.

According to this typology, levels 1 to 3 include the physical systems whose structures are highly rigid, constrained and limited. Levels 4 to 6 subsume the biological systems. Levels 7 to 8 involve the human and social systems. The level 9 is any imaginary level. Moving from level 1 to 8, the systems become progressively more complex and their structures become somewhat less rigid and constrained, and the connections between the interacting parts become relatively loose, where less constraint is placed on the behavior of one element by the condition of the others (SCOTT, 1998). Additionally, and most importantly, moving from level 1 to 8, the systems grow towards higher degrees of cognition, intelligence and autonomy.

From such analyses, it can be asserted that differences between theories of natural and social sciences reside not only in the properties and structure of their elements of study, but most importantly, in the abilities of these elements. The former refers to physical, biological and chemical attributes, and the latter means abilities to cognition, intelligence and autonomy. On one hand, the main elements of social systems are humans and networks of people, and also organizations and networks of organizations. Social systems possess high degrees of cognition, intelligence and autonomy which are distributed among their individuals and among their relationships. On the other hand, the elements of, and the relationships with, physical, biological and chemical systems, including all the objects and organisms of the ecological system, but excluding the man, are less complex than those found in social systems if we consider that they have low degrees of cognition, intelligence and autonomy (if any in most of the cases).

Therefore, the nature of a theory of organizations resides in principles of human behavior and cognition[3].

COGNITIVE DEFINITIONS OF THE ORGANIZATION

Organizations as Distributed Cognitive Agents

The definition of organizations introduced in this subsection represents a synthesis of the concepts presented in (CARLEY; GASSER, 1999; MARCH; SIMON, 1958; NOBRE *et al.,* 2008; SCOTT, 1998).

Firstly, organizations are assemblages of distributed cognitive agents. Agents are classified as natural or artificial, and living or nonliving. Humans are natural-living agents, while machines, and more specifically cognitive machines (NOBRE, 2005), are artificial-nonliving ones. Agents have cognitive, physical, temporal, institutional and spatial limitations (CARLEY; GASSER, 1999; NOBRE, 2008).

Secondly, organizations pursue a coordinative system rooted into a social structure which is composed by normative and behavioral parts (SCOTT, 1998). Coordinative systems of distinct organizations have different degrees of centralization and decentralization.

Thirdly, organizations pursue goals. The conception of goals varies from individual to organizational levels and also from technical, managerial and institutional to worldwide levels (NOBRE, 2008). The meaning of goals can range from the perspectives of rational, natural to open systems. Additionally, the strategy of satisfice[4] which

[3] The subject of emotions in organizations is left for further research. Perspectives about this topic can be found in (Bagozzi, et al 1998; Fineman, 1993; Keltner & Gross, 1999; Keltner & Haidt, 1999; Plutchik, 1982; Scherer, 1982).

[4] The term satisfice was coined by Herbert Simon (March & Simon, 1958). In resume, satisficing is a decision-making strategy which attempts to meet criteria for adequacy, rather than to identify an optimal solution.

attempts to meet criteria for goal adequacy, rather than goal optimization, is better applied to the organization since agents have limitations of cognitive resources to maximize (MARCH; SIMON, 1993).

Lastly, organizations are open systems, and therefore they pursue the skills of sensing from, and responding to the environment.

In conclusion, organizations are assemblages of distributed and interacting agents with a coordinative system. They are supposed to satisfy goals, and they have relations with the environment. In such a context, the term "satisfy" is synonymous with "satisfice" as defined by Simon (1997a).

Characteristics of the Organization

(i) The members of organizations are cognitive agents that participate in decision-making, problem solving and learning processes in the organization (MARCH; SIMON, 1993; NOBRE *et al.,* 2008; SIMON, 1997b).

(ii) Processes of decision-making involve trade-offs among alternatives which are characterized by uncertainty, incomparability and unacceptability, and hence they can lead organization members to intra-individual conflict. Additionally, members of groups in organizations differ in their perceptions and goals, and thus they can disagree in their decisions causing group conflicts (MARCH; SIMON, 1993; NOBRE, 2008).

(iii) The intra-individual and group conflicts which arise in organizations as exposed in (ii) are mainly determined by uncertainties and lack of information, and most importantly by cognitive limitations of humans. Hence, these conflicts cannot be solved by incentive and reward systems[5]. Such cognitive and information constraints are synonymous with bounded rationality (MARCH, 1994; MARCH; SIMON, 1993; NOBRE, 2008; SIMON, 1982, 1997a, 1997b). However, as proposed in (NOBRE, 2005, 2008; NOBRE *et al.,* 2008), cognitive machines can be used to reduce or to solve such conflicts in organizations.

(iv) The members of organizations have different perceptions. Such a differentiation is accentuated due to the variety of individual motives[6], and also because of the inequality of distribution of information among the participants in the organization. Therefore, it can lead the participants within the organization to group conflicts (MARCH; SIMON, 1993; NOBRE, 2008).

(v) The members of organizations have motives which differ from organization goals. Hence, organizations have to motivate them and to provide them with inducements (such as incentive and reward systems) which lead them to participate in organization activities, including decision-making, problem-solving and learning. If satisfactory alignment is found between the organization's goals and its participants' motives (GIBBONS, 1998), then organization equilibrium can be achieved (MARCH, SIMON, 1993; NOBRE, 2008).

(vi) Organizations shape participants' perceptions and behavior through social structure, technology and goals, and participants shape organizations through their culture, behavior, emotions, perceptions, motives and cognitive skills.

(vii) The environment shapes the social structure, technology, goals, participants and behavior of organizations, through its sources of complexity and uncertainty, and also through information, processes, technologies, among other elements.

(viii) Organizations also shape the environment through similar means.

[5] A tutorial on strategic reward systems is found in (Dunnette & Hough, 1992: 1009-1055).

[6] A Unified Model of Employee Motivation is presented in (Elding *et al*, 2006).

Organizations as Hierarchic Cognitive Systems

The classification of the organization in technical, managerial and institutional levels of analysis was initially proposed by Talcott Parsons (PARSONS, 1960). This paper borrows and supports his ideas and it also extends them to include a fourth level of analysis named worldwide

Technical Level

The technical system is concerned with cognitive tasks and general activities used for the development of goods and services. It comprises people, machines, communication systems and processes. This level depends on information and resources of the environment for the acquisition of new technologies, and also for the acknowledgement of compliance of goods and services with customers' requirements, technical, quality and general standards.

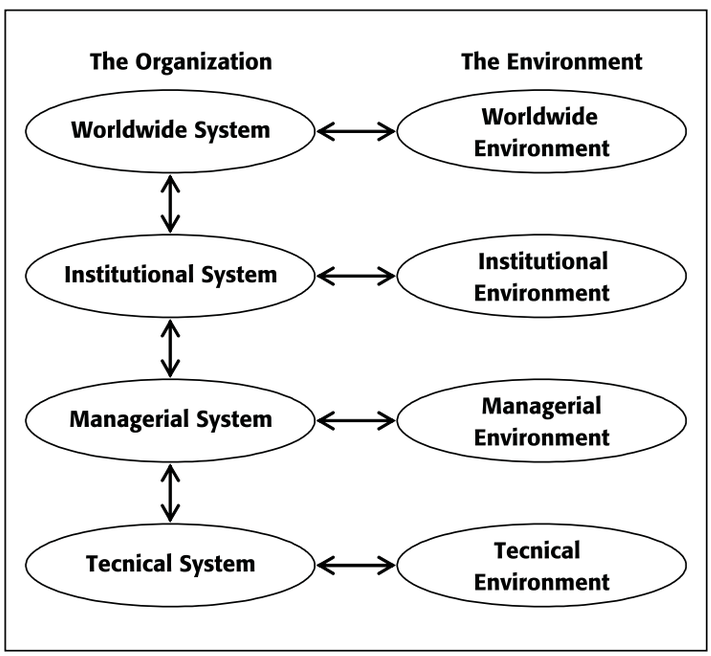
system. Moreover, these levels of analysis are introduced here in the context of cognitive organizational systems. Their meanings are described by the following paragraphs and Figure 4 illustrates the organization under such a perspective.

Managerial Level

The managerial system is concerned with cognitive tasks of analysis, design and redesign of the organization. In this level, the organization carries out activities of planning, control, coordination and innovation in the areas of goals and strategy; structure (normative structure, specialization, span of control, distribution of authority, departmentalization, *etc*); technology and processes[7] of acquisition, organization, processing, communication and sharing of

Figure 4

The Organization Levels of Analysis



[7] Processes of this kind can also involve process improvement models like CMM (Paulk *et al*, 1994), quality procedures like ISO 9000 and 14000, principles of management and production like just-in-time and lean-production, intranet and the knowledge to be shared within the organization, policies for recruiting and hiring agents (participants), procedures for evaluating agents and performance, etc.

information along with decision-making and learning; rewards (incentives and inducements); and human resources (recruiting, training, etc.). This level also needs a channel of communication with the environment in order to exchange information through practices benchmarking and other strategies. In such a way, the organization is in the pursuit of competitive advantage and acquisition of information such as on marketing strategies and the incentive and reward systems offered by other organizations and competitors. By connecting with the environment, the organization also can hire new talents, select and form new partnerships with buyers and suppliers, among other tasks. The managerial level is also a mediation level between technical and institutional systems.

Institutional Level

The institutional system is concerned with cognitive tasks used to mediate between the organization and its environment. It comprises the understanding of the social, political, cultural and economic contexts of the organization's environment. The cognitive tasks at this level shape both the technical and the managerial systems, and also the environment. At this level, participants have responsibility to understand regulative processes of the market which constrain the boundaries of action of the organization; to understand the cultural aspects of the organization and its environment; to manage the relationships between the organization and the networks of organizations which influence upon the business of the prime organization; to understand tax rules on the transaction of goods and services, labor union rights and laws; to set up broader goals and strategies for the organization, like its expansion to other geographical locations and markets, delineation of new products and services; to attract and to maintain a body of stakeholders; to form new joint ventures and partnerships; to analyze the wealth of the organization; to plan the percentage of the stocks to be shared in the market; to participate in the decision processes of design and redesign of the organization; among other tasks.

Worldwide Level

The worldwide system is concerned with cognitive tasks which connect the organization to the world and to the globalization. Such tasks involve the analysis of the implications of organizations, networks and populations of organizations for the social, cultural, economic, political and ecological contexts of the environment. It provides general analysis on the implications of organizations for the whole economy, for the world income distribution, for the Gross Domestic Product (GDP) per capita of a country, for people's social life, well-being, wealth and health, for the global ecosystem and its natural resources; for climate change and energy demand; and so on. Some prominent studies related to this level of analysis are presented in (EASTERLIN, 2000; JOHNSON, 2000; JONES, 1997; PRITCHETT, 1997; WORLD BANK, 2003).

MODELS OF COMPLEX ORGANIZATIONAL SYSTEMS

Complex Model of the Organization

Definition 3: The organization is a special type of dynamic system[8] characterized by a level of complexity C_L which is contingent upon its degree of cognition C_d, intelligence I_d and autonomy A_d.

Axiom 1: Considers that C_L is the level of complexity of an organization O_s and that C_d, I_d

[8] A dynamic system has time-varying interactions (Forrester, 1961). This paper views systems as defined in (Bunge, 1987; and Hall & Fagen, 1956). Additionally, it considers the organization as a system with memory - i.e. given the state of an organization O_s at a discrete time k, then it is assumed that $O_s(k+1) = O_s(k) + O_s(k-1)$.

and A_d are its degrees of cognition, intelligence and autonomy respectively. Moreover, assumes that C_L can be characterized by a function g of parameters C_d, I_d and A_d:

$$C_L = g(C_d , I_d , A_d) \mid 1 \geq C_L , C_d , I_d , A_d \geq 0 \quad (1)$$

$C_{L'}$, C_d, I_d and A_d are defined in the interval [0,1] since they can be characterized by using the concepts of fuzzy sets and membership functions[1] (ZADEH, 1965). The application of the fuzzy sets theory is encouraged to this definition of organizations because complexity, cognition, intelligence and autonomy are vague and loose concepts in the sense defined by Black (1937, 1963), and they also are fuzzy concepts in the way defined by Zadeh (1965, 1973). Therefore, C_L, C_d, I_d and A_d can be represented as matters of degree in the continuous interval [0,1].

Axiom 2: In such a way, let us define an organization O_s denoted here by an object u belonging to an universe of discourse U, which contains the all classes of organizations, i.e., (u_i Î U | $i=1,\ldots,N$), for N integer.

Axiom 3: Let us also define the level of complexity C_L, and the degrees of cognition C_d, intelligence I_d and autonomy A_d as fuzzy sets with their respective membership functions denoted by $\mu_{CL}(u)$, $\mu_{Cd}(u)$, $\mu_{Id}(u)$ and $\mu_{Ad}(u) \in [0,1]$, i.e.:

$$C_L = \{u \mid \mu_{C_L}(u) \in [0,1], u \in U\} \quad (2)$$

$$C_d = \{u \mid \mu_{C_d}(u) \in [0,1], u \in U\} \quad (3)$$

$$I_d = \{u \mid \mu_{I_d}(u) \in [0,1], u \in U\} \quad (4)$$

$$A_d = \{u \mid \mu_{A_d}(u) \in [0,1], u \in U\} \quad (5)$$

Therefore, O_s can assume four degrees of complexity, intelligence, cognition and autonomy respectively, where such degrees can be interpreted as degrees of compatibility or membership of O_s to the respective fuzzy sets C_L, C_d, I_d and A_d.

From equation (1), it can be stated that:

Definition 4: The level of complexity C_L is a function g which can be represented by a t-norm " or an s-norm ⊥ (DUBOIS, PRADE, 1985), i.e.:

$$C_L (\perp) = \{u \mid \mu_{CL}(u) = \mu_{(Cd \perp Id \perp Ad)} \in [0,1], u \in U\} \quad (6)$$

$$C_L (\cap) = \{u \mid \mu_{CL}(u) = \mu_{(Cd \cap Id \cap Ad)} \in [0,1], u \in U\} \quad (7)$$

Complex Model of the Environment

This subsection and the next one are about the environment e, and the relations R_e between the organization O_s and the environment e.

Axiom 4: Let us consider an organization O_{s1} with relations R_{e1} to an environment e_1, (O_{s1} "! R_{e1} "! e_1), which has relations R_{e2} to another environment e_2, (e_1 "! R_{e2} "! e_2). Therefore, a generic environment e_n of an organization O_{sn} form relations $R_{e(n+1)}$ to an environment $e_{(n+1)}$, (O_{sn} "! $R_{e(n+1)}$ "! $e_{(n+1)}$), where n is integer.

Axiom 5: Let us define a network N_E constituted by $(n+1)$ organizations $O_{s(i=1,\ldots,n+1)}$. Let us also define the organization O_{s2} as the environment of O_{s1} with relations R_{e1} between them, and O_{s3} as the environment of O_{s2} with relations R_{e2}. Therefore, it can be derived that $O_{s(n+1)}$ is the environment of O_{sn} with relations R_{en} between them: (O_{sn} "! R_{en} "! $O_{s(n+1)}$).

Axioms (4) and (5) also imply that an environment is a relative concept that depends on the perspective of our analysis on a map of networks of organizations. This means that the roles of e and O_s may be exchanged since an environment e can represent an organization O_s, and vice-versa, according to perspective that someone looks at the map of networks of organizations. Therefore:

Definition 5: Similarly to O_s, definitions (3) and (4) also apply to the environment *e,* where O_s is replaced with *e*.

Complex Relations between the Organization and the Environment

This subsection complements the definitions of the organization O_s and the environment *e* by introducing different types of relations R_e which can exist between them. It borrows and adapts the approach to the analysis of ecological dynamics presented in (BOULDING, 1978) in order to describe the diversity of relations R_e.

Axiom 6: Lets us assume an organization $O_s(t)$ with a set of state variables denoted by $\boldsymbol{X}(t)$, where *t* denotes time. Additionally, let us define the organization performance $P_{Os(t)}$ as a measure of its efficacy and efficiency which are dependent on the behavior of $\boldsymbol{X}(t)$.

Axiom 7: Similarly, let us consider an environment *e(t)* with state variables $\boldsymbol{Y}(t)$ and with performance denoted by $P_{e(t),}$ which holds the same assumptions given to $P_{Os(t)}$.

Axiom 8: Let us assume that $O_s(t)$ can affect *e(t)* in three ways. $O_s(t)$ may affect *e(t)* favorably, and hence the relation $R_e(t)$ is cooperative. A rise in $P_{Os(t)}$ will increase $P_{e(t)}$ (i.e., if $P_{Os(t)}$ '! then $P_{e(t)}$ '!). Secondly, the relationship $R_e(t)$ may be competitive. In this case, a rise in $P_{Os(t)}$ leads to a decline in $P_{e(t)}$ and a fall in $P_{Os(t)}$ causes a rise in $P_{e(t)}$ (i.e., if $P_{Os(t)}$ '! then $P_{e(t)}$ "! and if $P_{Os(t)}$ "! then $P_{e(t)}$ '!). Thirdly, $P_{e(t)}$ may have no dependence on $P_{Os(t)}$ and therefore a rise or a fall in $P_{Os(t)}$ may have no effect on $P_{e(t)}$ (i.e., if either $P_{Os(t)}$ '! or "! then $P_{e(t)}(0)$).

Similar relations can be postulated for the influence of *e(t)* on $O_s(t)$. In this case, new representations have to be derived. Therefore:

Axiom 9: Let us denote $R_{(e'!Os)}$ as the relations to the effect of *e(t)* on $O_s(t)$, and $R_{(Os'!e)}$ as the relations of $O_s(t)$ on *e(t)*.

The results of all possible combinations are represented in the Table 1, and Table 2 describes the results of such combinations.

Definition 6: Relations R_e are dynamical systems whose attributes can change over time. Examples of attributes applicable to these relations are competition and cooperation. R_e does not guarantee bilateral properties, i.e., the types of relations created from $O_s(t)$ to *e(t)* as given by $R_{(Os'!e)}$ may differ from the relations of $R_{(e'!Os)}$. Moreover, definitions (3) and (4) also apply to the concept of relations R_e between O_s and *e*.

Table 1

Classes of Relations $R_e(t)$

$R_{(Os \rightarrow e)}$ / $R_{(e \rightarrow Os)}$	Cooperative $P_{Os(t)} \uparrow \; P_{e(t)} \uparrow$	Competitive $P_{Os(t)} \uparrow \; P_{e(t)} \downarrow$	Independent $P_{Os(t)} \updownarrow \; P_{e(t)}(0)$
Cooperative $P_{e(t)} \uparrow \; P_{Os(t)} \uparrow$	1	4	7
Competitive $P_{e(t)} \uparrow \; P_{Os(t)} \downarrow$	2	5	8
Independent $P_{e(t)} \updownarrow \; P_{Os(t)}(0)$	3	6	9

Table 2

Analysis of Relations $R_e(t)$

Cases	Interpretation
1	*Os(t)* contributes to *e(t)* and *e(t)* contributes to *Os(t)*
2	*Os(t)* contributes to *e(t)* but *e(t)* harms *Os(t)*
3	*Os(t)* contributes to *e(t)* but *e(t)* has no effect on *Os(t)*
4	*Os(t)* harms *e(t)* but *e(t)* contributes to *Os(t)*
5	*Os(t)* harms *e(t)* and *e(t)* harms *Os(t)*
6	*Os(t)* harms *e(t)* but *e(t)* has no effect on *Os(t)*
7	*Os(t)* has no effect on *e(t)* but *e(t)* contributes to *Os(t)*
8	*Os(t)* has no effect on *e(t)* but *e(t)* harms *Os(t)*
9	*Os(t)* does not affect *e(t)* and *e(t)* does not affect *Os(t)*

Complex Networks of Organizations

An important result derived from axiom (5) and definition (5) is the concept of networks of organizations as outlined here.

Definition 7: A network of *(n+1)* organizations $O_{s(i=1,\ldots,n+1)}$ is a dynamic system denoted by $N_E(t)$ whose relations $R_{e(i=1,\ldots,n+1)}$ change over time.

Relations between organizations and the environment, including other organizations and the market, change over time. As an example, after the privatization of the telecommunications market in Brazil in the late of 1990's, most of the telecommunications companies in that environment lost part of their governmental customers, and since then, they had to find new solutions in order to survive (VOLPE; NOBRE, 2000).

CONCLUSIONS AND CONTRIBUTIONS

On Organizational Cognition

This paper put forwards cognition as a fundamental element of the organization. In summary, it proposed that:

(i) A theory of organizational cognition is important and necessary when we decide to design organizations with higher capabilities of information processing and uncertainty management. In such a way, organizational cognition is a discipline which contributes to improve the computational capacity of the organization along with its ability for knowledge management.

(ii) Organizational cognition plays an important part in organization design, and vice-versa, and also in the analyses of the relations between the organization and the environment.

To support such statements, this paper contributed with definitions, premises and propositions towards a theory of organizational cognition which comprises concepts of intelligence, autonomy and complexity for the organization, the environment and their relations. It proposed ten principles about organizational cognition and it clearly distinguished organizational cognition from the concept of organizational learning. It also introduced the concept of hierarchic levels of cognition in organizational systems and thus it set up cognition as a fundamental element of the organization.

On Organizational Cognition and Environmental Complexity

This paper borrowed the picture of organizations as contingent upon the environment from the perspective of organization design and contingency theory as proposed by Galbraith (1973, 1977, 2002). Moving further, it also relied on the proposition that an increase in organizational cognition reduces the relative levels of uncertainty and complexity of the environment with which the organization relates. Such perspectives were summarized by theorem (1):

Theorem 1: The higher the degree of cognition of the organization, the lower is the relative level of environmental complexity and uncertainty that the organization confronts and needs to manage.

According to the concept of Hierarchic Levels of Cognition presented in Section 9, organizational systems grow in complexity as they move from frameworks, mechanical and biological systems to social systems. It was defined that cognition, and thus degree of cognition, is the main element which makes organizational systems distinct from each other in terms of complexity, intelligence, autonomy and behavior. Organizations with higher degrees of cognition have higher levels of complexity along with higher degrees of intelligence and autonomy. Therefore, in this paper, organizational complexity was defined as synonymous with, and contingent upon, organizational cognition; and environmental complexity was defined as synonymous with, and contingent upon, environmental uncertainty.

Moreover, it was defined that organizational cognition is a matter of degree which is contingent upon organization design, i.e., the choice of the elements of the organization that subsume goals, social structure, participants and technology. Therefore, organizational cognition differs from human cognition if we consider the perspective that the former is part of an artificial process of design, while the latter is part of a natural and biological process.

Additionally, as a consequence of the contingency of the organization upon the environment, it was stated that organizations have different degrees of cognition when they operate in different environments.

Further Extensions

On Measurements of Organizational Cognition

As important as a theory of organizational cognition, is a complementary methodology to measure degrees of organizational cognition. In such a direction, the book research presented in (Nobre *et al.* 2008) has provided the literature with important directions to assess and to measure the degree of organizational cognition with basis on appraisal methods of continuous process improvement models. In his book, Nobre investigated an industrial case study where he associated the concept of degrees of organizational cognition with levels of organizational process maturity, capability and performance along with organizational learning results. Qualitative analyses and quantitative measurements of the industrial case study indicated that improvements in the levels of organization process maturity and organization process performance were associated with improvements in the degree of organizational cognition; and also that improvement in organizational learning could be associated with improvements in organizational cognition. This latter association is reinforced in the literature when improvements in organization performance and productivity are associated with the practices of organizational learning (ARGOTE, 1999).

On the Future of Organizations

While the characteristics of the elements of the organization will change, evolve and develop continuously towards higher levels of cognition and complexity, the purpose of existence of the organization will remain the same or will not change in the same proportion of its elements (NOBRE, 2008).

The former part, which is concerned with the elements of the organization, will move towards high levels of automation, and it will include machines with high degrees of cognition, intelligence and autonomy, mainly in those areas at upper layers and levels of the organization; and thus they will provide organizations with more capabilities of computational capacity along with knowledge and uncertainty management. Therefore, new organizations of this kind will be able to operate in, and to manage higher levels of environmental complexity than organizations of today. These transformations towards new organizations will have implications for the society and this is a topic of further research (NOBRE *et al.,* 2008).

The latter part, which is concerned with the purpose and the existence of organizations, will remain the same and for sure will not change in the same proportions to the evolutions in the organization elements. This is because the individual motives and the organizational goals which are pursued by human kind will not change over time into the political, economical and social facets of this world.

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